REMARKS

This is a full and timely response to the non-final Office Action mailed by the U.S. Patent and Trademark Office on June 17, 2005. Claims 1-21 remain pending in the present application. In view of the following remarks, reconsideration and allowance of the present application and claims are respectfully requested.

Election/Restriction

Applicants acknowledge with appreciation the withdrawal of the previous restriction requirement.

Double Patenting

Claims 1-21 stand rejected under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims 1-19 of U. S. Patent No. 6,762,480.

Applicants submit herewith a terminal disclaimer with respect to U.S. Patent No. 6,762,480 and respectfully request the withdrawal of the obviousness-type double patenting rejection.

Rejections Under 35 U.S.C. §102

Claims 1, 10, 12 and 21 stand rejected under 35 U.S.C. §102(e) as allegedly being anticipated by U.S. Patent No. 6,399,971 to Shigematsu *et al.* A proper rejection of a claim under 35 U.S.C. §102 requires that a single prior art reference disclose each element of the claim. *See, e.g., W.L. Gore & Assoc., Inc. v. Garlock, Inc.*, 721 F.2d 1540, 220 USPQ 303, 313 (Fed. Cir. 1983). Anticipation requires that each and every element of the claimed invention be disclosed in a single prior art reference. *See, e.g., In re Paulsen,* 30 F.3d 1475, 31 USPQ2d 1671 (Fed. Cir. 1994); *In re Spada*, 911 F.2d 705, 15 USPQ2d 1655 (Fed. Cir. 1990). Alternatively, anticipation requires that each and every element of the claimed invention be embodied in a single prior art device or practice. *See, e.g., Minnesota Min. & Mfg. Co. v. Johnson & Johnson Orthopaedics, Inc.*, 976 F.2d 1559, 24 USPQ2d 1321 (Fed. Cir. 1992). The test is the same for a process. Anticipation requires identity of the claimed process and a process of the prior art. The claimed process, including each step thereof, must have been described or embodied, either expressly or inherently, in a single reference. *See, e.g., Glaverbel S.A. v. Northlake Mkt'g & Supp., Inc.,* 45 F.3d 1550, 33 USPQ2d 1496 (Fed. Cir. 1995). Those elements must either be inherent or disclosed expressly. *See, e.g., Constant*

v. Advanced Micro-Devices, Inc., 848 F.2d 1560, 7 USPQ2d 1057 (Fed. Cir. 1988); *Verdegaal Bros., Inc. v. Union Oil Co.*, 814 F.2d 628, 2 USPQ2d 1051 (Fed. Cir. 1987). Those elements must also be arranged as in the claim. *See, e.g., Richardson v. Suzuki Motor Co.*, 868 F.2d 1226, 9 USPQ2d 1913 (Fed. Cir. 1989); *Carella v. Starlight Archery & Pro Line Co.*, 804 F.2d 135, 231 USPQ 644 (Fed. Cir. 1986). For anticipation, there must be no difference between the claimed invention and the reference disclosure, as viewed by a person of ordinary skill in the field of the invention. *See, e.g., Scripps Clinic & Res. Found. v. Genentech, Inc.*, 927 F.2d 1565, 18 USPQ2d 1001 (Fed. Cir. 1991).

Accordingly, the single prior art reference must properly disclose, teach or suggest each element of the claimed invention.

It is alleged in the Office Action that:

> The '971 reference discloses in figure 1, a hetrojunction bipolar transistor (HBT) comprising: a collector 14, an emitter 18; and a base 16 located between the collector and the emitter, the base including a layer of gallium arsenide antimonide (GaAsSb) (see column 9, line 45-59) less than 49 nanometers (nm) thick (see column 5, line 39). The reference also discloses base doping concentration of 1 * 10^{19} and the base is carbon doped (see column 5, lines 39-41,and claim 1)

Shigematsu et al. discloses a heterojunction bipolar transistor (HBT) having a base contact layer 30 fabricated using gallium arsenide antimonide (GaAsSb) and a base layer 16 that is fabricated using indium gallium arsenide (InGaAs). *See Shigematsu et al.*, column 5, lines 4-6 and column 5, lines 32-47. Importantly, the base contact layer 30 resides outside of the active area of the HBT. The base contact layer 30 is used to reduce the resistance between an intrinsic base region (the region of the base layer 16 immediately below the emitter layer 18) and the base electrode 32. *See Shigematsu et al.*, column 5, lines 18-27.

The base contact layer 30 is preferably 125 (nm) thick GaAsSb and is doped with carbon (C). *See Shigamatsu et al.*, column 6, lines 12-16. Importantly, nowhere does *Shigamatsu et al.* disclose, teach or suggest a base layer 16 having a high doping concentration. Indeed, as taught by *Shigematsu et al.*, the base contact layer 30 is heavily doped, not the base layer 16.

The base contact layer 30 is formed using a material having no indium (In), and is lattice matched to the material of the base layer 16. *See Shigematsu et al.*, column 6, lines 22-27. Further, *Shigematsu et al.*, in column 6, lines 55-57, discloses an HBT including a base layer 16 of carbon doped InGaAs and a base contact layer 30 of GaAsSb having a low resistance.

With regard to the statement in the Office Action that "*Shigematsu* discloses "a base 16 located between the collector and the emitter, the base including a layer of gallium arsenide antimonide (GaAsSb) (see column 9, line 45-59) less than 49 nanometers (nm) thick (see column 5, line 39)," Applicants respectfully submit that nowhere, in column 9, lines 45-59, or column 5, line 39, does *Shigematsu et al.* disclose an HBT having a base, wherein the base is gallium arsenide antimonide (GaAsSb) less than 49 nanometers (nm) thick and having a doping concentration greater than 6×10^{19} acceptors/cm^3.

Furthermore, while *Shigematsu et al.* indeed discloses, in column 5, line 39, that the base layer 16 can be 30 nanometers (nm) thick, *Shigematsu et al.* fails to disclose, teach or suggest a base layer of GaAsSb less than 49 nanometers (nm) thick and having a doping concentration greater than 6×10^{19} acceptors/cm^3.

In marked contrast to *Shigematsu et al.* the present invention includes a heavily doped ***base layer*** of GaAsSb, not a ***base contact layer*** of GaAsSb. Furthermore, the heavily doped base layer of the present invention is less than 49 nm thick. Applicants wish to clarify the difference between the base contact layer 30 of *Shigematsu et al.* and the thin, heavily doped base layer of the present invention. Applicants respectfully submit that the base contact layer 30 of *Shigematsu et al.* is outside of the active portion of the HBT, while the thin, heavily doped base layer of the present invention electrically affects the operation of the HBT of the invention. Specifically, the thin base layer of the present invention is heavily doped (resulting in a reduction in the current gain of the HBT), while the InGaAs base layer in *Shigematsu et al.* is very lightly doped.

As Applicants pointed out in their disclosure, one of the features that permits the use of the thin base is the heavy base doping. *Shigematsu et al.*, on the other hand, uses a very lightly doped base layer of InGaAs (doped on the order of $1x10^{19}$ cm^{-3} (see column 5, lines 39-40 of *Shigematsu et al.*)), but then uses a heavily doped base contact layer of GaAsSb. Applicants respectfully submit that the use of the heavily doped base contact layer by *Shigematsu et al.* is obviated by Applicants' invention. Indeed, the presence of the heavily doped base contact layer in *Shigematsu et al.* is evidence that *Shigematsu et al.* never considered using a thin, heavily doped base layer of GaAsSb.

Specifically, and with particular regard to the claims, independent claim 1 includes at least "a base located between the collector and the emitter, the base including a layer of gallium arsenide antimonide (GaAsSb) less than 49 nanometers (nm) thick and having a doping concentration greater than 6×10^{19} acceptors/cm^3." Similarly, independent claim 12

includes at least the step of "forming a base located between the collector and the emitter, the base including a layer of gallium arsenide antimonide (GaAsSb) less than 49 nanometers (nm) thick and having a doping concentration greater than 6 X 10^{19} acceptors/cm^3." Applicants respectfully submit that *Shigematsu et al.* fails to disclose, teach or suggest these features.

Rejections Under 35 U.S.C. §103

Claims 2-8, 11 and 13-19

Claims 2-8, 11 and 13-19 stand rejected under 35 U.S.C. §103(a) as allegedly being unpatentable over *Shigematsu et al.* and further in view of U.S. Patent No. 5,770,868 to Gill. For a claim to be properly rejected under 35 U.S.C. §103, "[t]he PTO has the burden under section 103 to establish a *prima facie* case of obviousness. It can satisfy this burden only by showing some objective teaching in the prior art or that knowledge generally available to one of ordinary skill in the art would lead that individual to combine the relevant teachings of the references." *In re Fine*, 837 F.2d 1071, 5 U.S.P.Q.2d 1596, 1598 (Fed. Cir. 1988) (citations omitted). Further, "[t]he mere fact that the prior art may be modified in the manner suggested by the Examiner does not make the modification obvious unless the prior art suggested the desirability of the modification." *In re Fritch*, 972 F.2d 1260, 1266, 23 U.S.P.Q.2d 1780 (Fed Cir. 1992).

Claims 2-6, 8, 11 and 13-17

It is stated in the Office Action that:

> Regarding claims 2-6, 8, 11 and 13-17, the '971 reference discloses the limitations in the claims, as discussed above, except for expressly stating a range of arsenic fraction, in the base, of 50% to about 51%, 65%, 60%, or 54%-56%, or approximately 55%. Gill teaches in figure 2, and column 3, that a fraction of 50% As in an AlGaAsSb layer would change the bandgap of the layer, and it will match the lattice constant of the layer more closely with an adjacent Indium containing layer. Therefore, it would have been obvious to one ordinary skill in the art at the time of the invention to adjust the percentage of Arsenic in the base layer of the '971 to about 50%, to match the lattice constant of the base to that of emitter and collector, and to avoid the lattice deformation that would result from lattice mismatch between the base and the collector/emitter layers.

Gill discloses a manner of fabricating a high indium-containing semiconductor layer over a gallium arsenide substrate by placing an aluminum gallium arsenide antimonide buffer layer between the high indium-containing layer and the gallium arsenide substrate. *Gill* states

that "[a]n indium-containing deposited semiconductor base material 16 is supported by a buffer layer 18 of FIG. 1, and is ultimately supported by bulk substrate 12. Semiconductor base material 16 consists essentially of $In_xGa_{1-x}As$ (Indium Gallium Arsenide), $In_xAl_{1-x}As$ (Indium Aluminum Arsenide), or $InAs_xP_{1-x}$ (Indium Arsenic Phosphide)." *See Gill*, column 3, lines 6-10. *Gill* continues stating that "[i]n accordance with an aspect of the invention, buffer layer 18 of FIG. 1 is a compositionally graded lattice matching material, which matches the lattice constant of the substrate 12, 26 to that of the high-indium semiconductor base material." *See Gill*, column 3, lines 16-20. *Gill* continues "[i]n accordance with another aspect of the invention, the Group III elements are Al (aluminum) and Ga (gallium) and the Group V elements are As (arsenic) and Sb (antimony). In a preferred embodiment of the invention, the flux of the Group III elements and of the antimony of the buffer layer are held constant as a function of the thickness of the buffer layer, and the flux of As is varied as a function of the thickness of the buffer layer, thereby resulting in a change in the ratio of the Group V atoms and a change in the lattice constant." *See Gill*, column 3, lines 26-35.

From this it is clear that the buffer layer in *Gill* merely comprises a graded composition layer in which the lattice constant of the buffer layer is varied with thickness to accommodate the placement of a high-indium containing base layer over a gallium arsenide substrate.

With respect to the Examiner's statement that

> Gill teaches in figure 2, and column 3, that a fraction of 50% As in an AlGaAsSb layer would change the bandgap of the layer, and it will match the lattice constant of the layer more closely with an adjacent Indium containing layer. Therefore, it would have been obvious to one ordinary skill in the art at the time of the invention to adjust the percentage of Arsenic in the base layer of the '971 to about 50%, to match the lattice constant of the base to that of emitter and collector, and to avoid the lattice deformation that would result from lattice mismatch between the base and the collector/emitter layers

Applicants respectfully submit that *Gill* fails to remedy the defects of *Shigematsu et al.* in that the proposed combination fails to disclose, teach or suggest each element of independent claims 1 and 12.

Further, while the Examiner states that "Gill teaches in figure 2, and column 3, that a fraction of 50% As in an AlGaAsSb layer would change the bandgap of the layer, and it will match the lattice constant of the layer more closely with an adjacent Indium containing layer," Applicants respectfully submit that Applicants' base layer does not contain indium. As stated above, Applicants independent claim 1 states, in part, "a base located between the collector

and the emitter, the base including a layer of gallium arsenide antimonide (GaAsSb) less than 49 nanometers (nm) thick and having a doping concentration greater than 6 X 10^{19} acceptors/cm^3." Further, Applicants' claim 12 states, in part, "forming a base located between the collector and the emitter, the base including a layer of gallium arsenide antimonide (GaAsSb) less than 49 nanometers (nm) thick and having a doping concentration greater than 6 X 10^{19} acceptors/cm^3." Applicants respectfully submit that the proposed combination fails to disclose teach or suggest at least these features.

Further, Applicants respectfully disagree with the statement in the Office Action that:

> it would have been obvious to one ordinary skill in the art at the time of the invention to adjust the percentage of Arsenic in the base layer of the '971 to about 50%, to match the lattice constant of the base to that of emitter and collector, and to avoid the lattice deformation that would result from lattice mismatch between the base and the collector/emitter layers.

Applicants respectfully submit that the As fraction in the GaAsSb base layer is varied to adjust the conduction band energy (*i.e.*, the energy band lineup), and not to match the lattice constant of the base to that of the emitter and collector, as stated in the Office Action.

For at least the reasons stated above, Applicants respectfully submit that the proposed combination fails to disclose, teach or suggest each element in independent claims 1 and 12. Further, Applicants respectfully submit that dependent claims 2-6, 8, 11 and 13-17 are allowable for at least the reason that they depend from allowable independent claims. *In re Fine, supra.*

Claims 7 and 18

It is stated in the Office Action that:

> Regarding claims 7 and 18, the '971 reference discloses the limitations in the claims, as discussed above, except for the base layer is less than 20 nm thick. However, it would have been obvious to one of ordinary skill in the art at the time of the invention to make the base layer as thin, in accordance with the miniaturization of electronic components that is ongoing, and favorable in the semiconductor chip manufacturing industry.

Applicants respectfully submit that the proposed combination of *Shigematsu et al.* and *Gill* fails to disclose teach or suggest a base layer of GaAsSb that is less than 20 nm thick. The doping concentrations disclosed in the present invention allow the thickness of the base layer to be reduced to the thickness claimed in claims 7 and 18. As mentioned above, *Shigematsu et al.* uses a very lightly doped base (on the order of $1x10^{19}$ (see column 5, lines

32-47 of *Shigematsu et al.*)), but then uses a heavily doped base contact layer. Applicants respectfully submit that the use of the heavily doped base contact layer in *Shigematsu et al.* is obviated by Applicants' invention. Indeed, the presence of the heavily doped base contact layer in *Shigematsu et al.* is evidence that *Shigematsu et al.* never considered using a thin, heavily doped base of GaAsSb. Further, *Gill* discloses a high-indium content base and fails to make any mention whatsoever regarding base thickness or doping levels.

No Motivation to Combine *Shigematsu et al.* with *Gill*

Applicants respectfully submit that there is no motivation to combine *Shigematsu et al.* with *Gill* to arrive at the present invention. "Obviousness cannot be established by combining the teachings of the prior art to produce the claimed invention, absent some teaching or suggestion supporting the combination. Under section 103, teachings of references can be combined only if there is some suggestion or incentive to do so." *ACS Hospital Systems, Inc., v. Montefiore Hospital*, 732 F.2d 1572, 1577, 221 USPQ 929, 933 (Fed. Cir. 1984). Further, "[t]here must be some reason, suggestion, or motivation found in the prior art whereby a person of ordinary skill in the field of the invention would make the combination." *In re Oetiker*, 977 F.2d 1443, 1447, 24 USPQ2d 1443 (Fed. Cir. 1992).

In *In re Sang-Su Lee*, 277 F.3d 1338, 61 USPQ2d 1430 (Fed Cir. 2002), the United States Court of Appeals for the Federal Circuit, reviewing an obviousness rejection by a Patent Examiner that was upheld by the Board of Patent Appeals and Interferences, stated:

> [t]he "common knowledge and common sense" on which the Board relied in rejecting Lee's application are not the specialized knowledge and expertise contemplated by the Administrative Procedure Act. Conclusory statements such as those here provided do not fulfill the agency's obligation....
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> ....
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> ...The patent examiner and the Board are deemed to have experience in the field of the invention; however, this experience, insofar as applied to the determination of patentability, must be applied from the viewpoint of "the person having ordinary skill in the art to which said subject matter pertains," the words of section 103.
>
> In finding the relevant facts, in assessing the significance of the prior art, and in making the ultimate determination of the issue of obviousness, the examiner and the Board are presumed to act from this viewpoint. Thus, when they rely on what they assert to be general knowledge to negate patentability, that knowledge must be articulated and placed on the record. The failure to do

> so is not consistent with either effective administrative procedure or effective judicial review. The board cannot rely on conclusory statements when dealing with particular combinations of prior art and specific claims, but must set forth the rationale on which it relies.

In Re Sang-Su Lee, 277 F.3d at 1345.

Applicants respectfully submit that there is nothing in *Shigematsu et al.* and *Gill* that would motivate one having ordinary skill in the art to combine these references to arrive at the thin base disclosed in the present invention. Further, the proposed combination fails to provide either a reasonable expectation of success of combining the references to achieve the thin base of the invention, or show any relevance to the problem solved by Applicants' invention. Further, the Office Action fails to articulate a clear motivation to make the proposed combination.

Specifically, Applicants respectfully submit that the Office Action fails to establish a prima facie case of obviousness because the Office Action has not pointed out the specific teachings in *Shigematsu et al.* and *Gill* that would motivate one having ordinary skill in the art to combine the references to arrive at Applicants' invention. Indeed, neither *Shigematsu et al.* nor *Gill* disclose, teach or suggest a thin, heavily doped base layer.

Further, Applicants respectfully disagree with the conclusory statement in the Office Action that:

> [h]owever, it would have been obvious to one ordinary skill in the art at the time of the invention to make the base layer as thin, in accordance with the miniaturization of electronic components that is going on, and favorable in the semiconductor chip manufacturing industry.

Applicants respectfully submit that one having ordinary skill in the art would not be led toward the claimed base thickness because *Shigematsu et al.* suggests a lightly doped base, while the thin base disclosed in the invention is heavily doped. Further, thinning the base to the scale described in Applicants disclosure would have minimal impact on the overall scale of the completed device.

For at least the reasons stated above, Applicants respectfully submit that the proposed combination fails to disclose, teach or suggest each element in dependent claims 7 and 18. Furthermore, Applicants respectfully submit that dependent claims 7 and 18 are allowable for at least the reason that they depend from allowable independent claims 1 and 12, respectively. *In re Fine, supra.*

Claims 9 and 20

Claims 9 and 20 stand rejected under 35 U.S.C. §103(a) as allegedly being unpatentable over *Shigematsu et al.* and further in view of U.S. Patent No. 5,349,201 to Stanchina.

It is stated in the Office Action that:

> The '971 reference, and the '971 reference in view of Gill, discloses the claimed invention, as discussed above, except for the base layer is doped with Be.
>
> Stanchina discloses at column 3, lines 39-47, an HBT with Be doped GaAsSb base layer provides improved performance over conventional HBTs by increasing the hole mobilities and valence band offset. Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to use this material in the HBT structure of the primary reference to increase the performance of the structure.

Stanchina et al. discloses a heterojunction bipolar transistor (HBT) that includes a base layer that is preferably 65 nanometers (nm) thick. Specifically, in a preferred embodiment, *Stanchina et al.* requires that the base layer 16 includes a 50 nm thick main layer 16a doped with beryllium (Be) to a free carrier concentration of approximately 3 to 6×10^{19} holes/cm^3, with the preferred value being 5×10^{19}, and a spacer layer 16b disposed between the main layer 16a and the collector layer 14. The spacer layer 16b is preferably 15 nm thick, and doped with beryllium to a free carrier concentration of 2×10^{18} holes/cm^3 (see column 3, lines 29-38). Specifically, *Stanchina et al.* requires a base thickness of at least 65 nm.

Applicants respectfully submit that the base doping concentration of between approximately $6x10^{19}$ and $4x10^{20}$ acceptors/cm^3 is the salient feature of claims 9 and 20 and not the base dopant. Applicants respectfully submit that the proposed combination fails to disclose, teach or suggest base doping using Be at a concentration of between approximately $6x10^{19}$ and $4x10^{20}$ acceptors/cm^3 as recited in claims 9 and 20.

No Motivation to Combine *Shigematsu et al.* with *Stanchina*

Applicants respectfully submit that there is no motivation to combine *Shigematsu et al.* with *Stanchina* to arrive at the present invention.

Applicants respectfully submit that there is nothing in *Shigematsu et al.* and *Stanchina*

that would motivate one having ordinary skill in the art to combine these references to arrive at the base doping concentration recited in claims 9 and 20. Further, the proposed combination fails to provide either a reasonable expectation of success of combining the references to achieve the invention, or show any relevance to the problem solved by Applicants' invention. Further, the Office Action fails to articulate a clear motivation to make the proposed combination.

Specifically, Applicants respectfully submit that the Office Action fails to establish a prima facie case of obviousness because the Office Action has not pointed out the specific teachings in *Shigematsu et al.* and *Stanchina* that would motivate one having ordinary skill in the art to combine the references to arrive at Applicants' invention. Indeed, neither *Shigematsu et al.* nor *Stanchina* disclose, teach or suggest the doping concentration recited in claims 9 and 20.

Further, Applicants respectfully disagree with the conclusory statement in the Office Action that:

> [t]herefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to use this material in the HBT structure of the primary reference to increase the performance of the structure.

Applicants respectfully submit that one having ordinary skill in the art would not be led toward the claimed doping concentrations because neither *Shigematsu et al.* nor *Stanchina* suggests the base doping concentration recited in claims 9 and 20.

For at least the reasons stated above, Applicants respectfully submit that the proposed combination is improper, and further, that the proposed combinations fail to disclose, teach or suggest the all elements of the invention

For at least the reasons stated above, Applicants respectfully submit that the proposed combination fails to disclose, teach or suggest each element in dependent claims 9 and 20. Furthermore, Applicants respectfully submit that dependent claims 9 and 20 are allowable for at least the reason that they depend from allowable independent claims 1 and 12, respectively. *In re Fine, supra.*

CONCLUSION

For at least the foregoing reasons, Applicants respectfully request that all outstanding rejections be withdrawn and that all pending claims of this application be allowed to issue. If the Examiner has any comments regarding Applicants' response or intends to dispose of this matter in a manner other than a notice of allowance, Applicants request that the Examiner telephone Applicants' undersigned attorney.

Respectfully submitted,

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